Phys - 725 SOLID STATE PHYSICS I Fall – 2025

Course Information

Instructor: Dr. Igor Ostrovskii

- **Lecture: T, Th 9:30 – 10:45, Room 228 Lewis Hall**
- **Office: Room 207 Lewis Hall**
- **Office Hours: Th 3:30 – 4:30 p.m. (207 Lewis Hall), and by appointment.**
- **Email: iostrov@phy.olemiss.edu [***I respond to emails on weekdays, and in a typical week you can expect a reply from me within 24-48 hours.***]**

Course Description

This course is devoted to the current basis of broad knowledge in Solid State and Condensed Matter physics. The course covers physical basis of numerous contemporary applications of Solid-State Physics in the fields of fundamental physics research involving interaction of elementary excitations, such as phonons and electric charge carriers. Applications in semiconductors and sensors are also considered.

LEARNING OBJECTIVES

1. Introduce physics graduate students to Solid State Physics including crystal structure, crystal binding, phonons and electrons in crystals, semiconductors, energy bands and Fermi surfaces.
2. Advanced understanding of the ideas of quantum physics applications to the solid state and condensed matter physics.
3. Enhance critical thinking, analytical reasoning, and problem-solving skills for graduate level.
4. Expand awareness of a scientific basis for advancements in contemporary scientific and technological issues.

To ensure appropriate professional practice and training experience:

5. When teach the physical basis of major contemporary applications of Solid-State Physics, to prompt learners to search for the publications in the scientific Journals for a particular physics phenomenon or effect.
6. Graduate students will know how to use interactive methods and Internet for their independent learning on "Solid State Physics I" especially those parts that describe the latest results in Solid State and its contemporary applications.
7. Learners will make the appropriate scientific presentations.

To ensure ongoing graduate student engagement in research:

8. Since in this course we introduce the graduates to the latest results in "Solid State Physics," they will have enough knowledge to understand **contemporary needs in new high-technology applications and practical solutions.**

SCHEDULE OF COVERED TOPICS AND READINGS:

1. Ch. 1: **CRYSTAL STRUCTURE.** [3.5 Classes]
Fundamental types of crystal lattices. Simple crystal structures. Superlattices. Modern experimental methods of direct imaging of atomic structure.

2. Ch.2: **WAVE DIFFRACTION AND THE RECIPROCAL LATTICE**. [2.5 Classes]
Diffraction of X-rays and matter waves by crystals. Brillouin Zones.

3. Ch. 3A: **SURFACES AND CRYSTAL BINDING, COHESION.** [4 Classes]
Binding in the crystals of inert gases, ionic crystals, covalent crystals, metals. Hydrogen bonds.

4. Ch.4: **PHONONS I: CRYSTAL VIBRATIONS**. [3 Classes]
Vibrations of crystals with monatomic basis. Two atoms per primitive basis. Quantization of elastic waves. Phonon momentum. Inelastic scattering by phonons.

- **MIDTERM TEST (Class #14) → Thursday, October 9**

5. Ch.5: **PHONONS II: THERMAL PROPERTIES.** [3 Classes]
Phonon heat capacity. Anharmonic crystal interactions. Thermal conductivity.

6. Ch.6: **FREE ELECTRON FERMI GAS.** [5 Classes]
Energy levels in one dimension. Effect of temperature on the Fermi-Dirac distribution. Free electron gas in three dimensions. Heat capacity of the electron gas. Electrical conductivity and Ohm's law. Hall Effect. Thermal conductivity of metals.

7. Ch. 7: **ENERGY BANDS.** [2 Classes]
Nearly free electron model. Bloch functions. Kronig-Penney Model. Wave equation of electron in a periodic potential.

8. Ch. 8: **SEMICONDUCTOR CRYSTALS.** [3 Classes]
Band gap. Equations of motion. Intrinsic carrier concentration. Impurity conductivity. Thermoelectric Effects. Semimetals. Superlattices.

9. Review session for Final Examination [0.5 Class]

10. ***STUDENT PRESENTATIONS*****:** [0.5 Class]

- **FINAL EXAMINATION → Thursday, December 11, 8 a.m. - 11 a.m.**

- The dates of chapter tests are tentative, and may be changed, **BUT NOT the FINAL EXAMINATION.**

Course Learning Outcomes

By the end of this course, the graduate students will be able to do as follows:

1. Understand the basic principles of Solid-State Physics.
2. Be aware and in depth understand the most important results in Physics of Solids that were

discovered and developed mainly in the second half of 20th century. *including following:*

Crystal structure, Crystal lattice, Binding in solids, Phonons and Thermal properties, Properties of the electrons in solids, Band theory of solids, Semiconducting properties of solids, Point defects in solids.

3. Learners will build on critical thinking, analytical reasoning, and problem-solving skills at a level of MS and Ph. D. candidates.

4. They will know about the problems in Solid State applications, and practical problems confronting Solid State physics in 21st century.

5. MS and Ph. D. candidates will know about main Nobel Prize awards in the field of Solids and Condensed matter.

Fostering independent learning: knowledge of the literature of a discipline

6. Discuss the problems confronting physics of solids in the 21-st century based on the results developed mainly in 2nd half of 20th century.

7. Learners will be recommended additional reading including research publications in particular professional Journals relevant to their individual research on advanced degree in Physics.

Course Texts and Materials

- **Main reading:**

1) Introduction to Solid State Physics, by Charles Kittel, 8-th edition. ISBN-10: **047141526X** | ISBN-13: **978-0471415268.** We cover chapters 1 through 8 and 20.

- **Additional reading:**

2) Condensed Matter Physics, by Michael P. Marder, 2nd edition (selected chapters), Published by John Wiley and Sons, Inc. ISBN: 978-0-470-61798-4 (Print); ISBN: 978-0-470-94994-8 (E-Book).

Major Assignments

1. ***EXAMS may not be "worked out," EXAM at its day/time will be the only one.***
2. **Homework** is assigned after some sections are covered and **is due in a week**.
3. Homework paper should be 8.5 x 11 inches with no torn or tattered edges. Homework papers should be stapled.
4. Show all your work; the answer alone is not worth anything. Homework must include main principles, diagrams, explanations, enough English to be understandable.
5. **Important**: **Circle the finale answers that you want to be graded**.
6. Graduate students of this class will be given a particular homework consisting a presentation of a research topic of their choice, or to present in extended format a particular section from the text.
7. Alternatively, the learners may choose to give a talk on latest results in the field, for example, "Nobel Prize in Physics", applications of Nano-Sciences & Engineering, etc.

Course Grading

UM Grade points per credit hour are assigned as follows: A = 4.0; A- = 3.7; B+ = 3.3; B = 3.0; B- = 2.7; C+ = 2.3; C = 2.0; C- = 1.7; D = 1.0; F = 0

This course: GRADING SCALE

A's ---------- 89 – 100
B's ---------- 79 – 88
C's ---------- 69 – 78
D's ---------- 59 - 68

EVALUATION:

Grades are based on: The home works, midterm test, **class activity**, presentation, and final examination: Homework ---25%; Midterm test --- 19%; Class activity ---15 % for no absences, Presentation --- 11%; Final exam ---30 %; **TOTAL = 100 points**

Course Policies

1. Class Attendance Policy:

UM Attendance guidelines: If a **student informs** an instructor in advance about an anticipated absence and the instructor decides not to provide an accommodation for a major exam or assessment, the student may appeal to the department chair or program director (or dean, when the instructor is chair or program director) who oversees the course. An appeal must be based on **(a)** failure of the instructor to articulate a policy, **(b)** failure of the instructor to follow the articulated policy, or **(c)** failure by the instructor to offer a reasonable accommodation for a documented absence that caused a student to miss an assessment that is **worth 20% or more of the course grade**. [Based on UM "Class Attendance Guidelines,"**- No accommodations for missed midterm test will be made.**]

2. Classroom Environment:

IN CLASS: *Turn off your phones before class! You are expected to be civil to others in the class.*

3. Academic Integrity:

The Faculty Senate produced the document, which encourages faculty members to include the following text in their syllabi: "All materials distributed electronically and in hard copy in this class are protected under intellectual copyright. Any attempt to upload these documents onto the Internet (or to distribute them by some other means) or to profit from the distribution (by Internet or other means) of these documents **constitutes theft and will be in violation of intellectual property law and the UM Academic Conduct Code unless expressly permitted for by the instructor**. Accessing such materials for your own use is also in violation of the UM Academic Conduct Code. Additionally, the distribution of your own class notes via the Internet or other means, or access of such materials, encourages absence from class and is highly discouraged."

4. Use of Generative Artificial Intelligence:
Students may use Generative Artificial Intelligence (AI) for their homework and course materials outside class. **Usage of AI is not allowed during Midterm test and Final Examination.**

5. Technology in the Classroom:
Students may use during Midterm test and Final Examination their **basic calculator without the advanced storage features**, such as programmable or graphing calculators.

Disability Access and Inclusion Statement/Policy

This course adopts the university statement below:

The University of Mississippi is committed to the creation of inclusive learning environments for all students. If there are aspects of the instruction or design of this course that result in barriers to your full inclusion and participation, or to accurate assessment of your achievement, please contact the course instructor as soon as possible. Barriers may include, but are not necessarily limited to, timed exams and in-class assignments, difficulty with the acquisition of lecture content, inaccessible web content, and the use of non-captioned or non-transcribed video and audio files. ***If you are registered with SDS, you must log in to your Rebel Access portal at rebel-access-portal to request approved accommodations.***

If you are NOT registered with SDS, you must complete the process to become registered. To begin that process, please visit our SDS website at apply-for-services. SDS will:

1. Complete a comprehensive review to determine your eligibility for accommodations,

2. If approved, disseminate to your instructors a Faculty Notification Letter,

3. Facilitate the removal of barriers, and

4. Ensure you have equal access to the same opportunities for success that are available to all students.

Course Schedule

1. Lectures from the 1st to 13th : We cover material of chapters 1, 2, 3 and 4 of C. Kittel textbook.
2. **MIDTERM TEST** (chapters 1, 2, 3,4) **(Class #14) → Thursday, October 9**
3. Lectures 15th to 27th : We cover material of chapters 5, 6, 7 and 8 of C. Kittel textbook.
4. Lecture # 28 is reviewing for Final exam. (0.5 class) and student presentations (0.5 class).
5. **FINAL EXAMINATION: Thursday, December 11, 8 a.m. - 11 a.m.**

The date of Midterm test is tentative, **BUT the FINAL EXAMINATION date is unchangeable.**